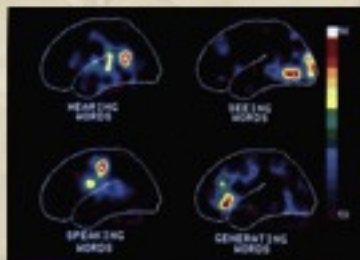


Reduction and Multiple Realizability: What Can Psychology Learn from the Brain?



Theory Reduction Model

Reduction as a deductive relation between laws or theories:

Lower-level theory (Neuroscience)

Bridge principles

Boundary conditions

∴ Upper-level theory (Psychology)

Fodor's account of what reduction would involve:

(1) $S_1x \Rightarrow S_2x$

(2a) $S_1x \leftrightarrow P_1x$ Bridge principle/Identity Claim

(2b) $S_2x \leftrightarrow P_2x$ Bridge principle/Identity Claim

(3) $P_1x \Rightarrow P_2x$

From 3, 2a, and 2b, one can derive 1

Variations on Physicalism According to Fodor

- Token Physicalism (Identity Theory): "all the events that the sciences talk about are physical events"
- Materialism: "token physicalism is true *and* that every event falls under the laws of some science or other"
-
- Type Physicalism (Identity Theory): "every *property* mentioned in the laws of any science is a physical property"
- Reductivism: "the conjunction of token physicalism with the assumption that there are natural kind predicates in an ideally completed physics which correspond to each natural kind predicate in any ideally completed special science"
 - "entails the generality of physics in at least the sense that any event which falls within the universe of discourse of a special science will also fall within the universe of discourse of physics"

Clicker Question

From the fact that both octopi and humans suffer pain, Putnam inferred what?

- A. It is immoral to harm members of either species
- B. That octopi and humans must have brain processes in common
- C. Feeling pain cannot be identified with brain processes
- D. Pain is a pre-scientific category--part of folk psychology--that must be replaced in real science



The Multiple-Realizability Argument

- In the 1960s Hilary Putnam argued that pain could be realized in a wide variety of species with very different brains
- Pain could not be identified with any given brain state
 - Identity theory was therefore false
 - Functionalism offered the only promise



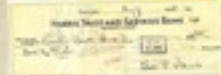
Clicker Question

From Fodor's perspective, if I know that a CD I want to buy in Paris costs €2.50, what must I also know to figure out the price in US\$?

- A. Nothing, it is obvious just from these facts
- B. The psychological laws affecting buyers and sellers
- C. The economic laws affecting currencies and exchange rates
- D. The neuroscientific laws affecting buyers and sellers

Relating Money to Physics

- Diversity of things that count as money
 - Strings of wampum
 - A signed check
 - A French 100 franc note
 - A US silver dollar
 - A wire transfer by computer
 - Bits in a computer
 - Etc.
- These various instances of money are not likely to have anything physical in common
- Since bridge law relating money to physical objects must also apply to counter-factual cases—to whatever might count as money in the future
 - There aren't any bridge laws and no reduction



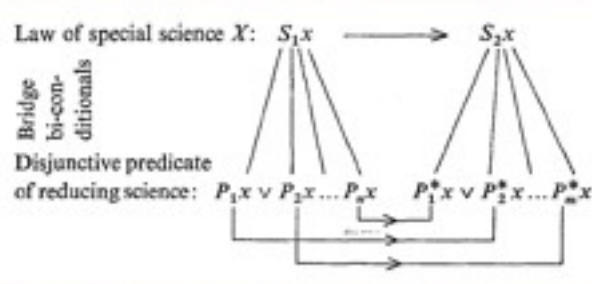
Betting Against Reductivism

- a. "interesting generalizations (e.g., counter-factual supporting generalizations) can often be made about events whose physical descriptions have nothing in common
- b. "it is often the case that *whether* the physical descriptions of the events subsumed by these generalizations have anything in common is, in an obvious sense, entirely irrelevant to the truth of the generalizations, or to their interestingness, or to their degree of confirmation or, indeed, to any of their epistemologically important properties, and
- c. "the special sciences are very much in the business of making generalizations of this kind"

Relating Psychology to Neuroscience

- "If psychology is reducible to neurology, then for every psychological natural kind predicate there is a co-extensive neurological natural kind predicate, and the generalization which states this co-extension is a law"
- "There are no firm data for any but the grossest correspondence between types of psychological states and types of neurological states, and it is entirely possible that the nervous system of higher organisms characteristically achieves a given psychological end by a wide variety of neurological means"

Special Science Laws Subsume Disjunctive Lower-Level Kinds



Positive Results

- Fodor claims to have explained the fact that the laws of the special sciences have exceptions
 - Explained by the fact that the bridge principles relates some instances of the kinds in the special sciences to instances outside the corresponding physical kind
- He has also given reasons for the endurance of the special sciences as autonomous from more basic sciences
 - They discover generalizations that are important to us
 - How someone is likely to behave if we threaten them
 - Their taxonomies cross-cut those of physics
 - Hence, they incorporate laws that physics cannot

Multiple Realizability Became Orthodoxy

- During the 1980s and 1990s multiple realizability became orthodoxy
- Defenders of identity theory (Kim, Hooker, Churchland) held out the hope of separate reductions for each realizer, as seemed to apply in physics
 - Temperature in a gas = mean molecular energy
 - Temperature in a solid = mean maximal molecular kinetic energy
- Question: are the number of different realizers tractable in psychology?
 - If even two humans have different brains but can think the same thought, then no hope of saving Identity Theory
 - And psychology has little to gain from neuroscience

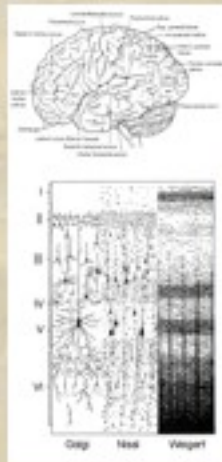
Psychology Re-engages the Brain

- From 1950 to late 1980s, there seemed to be little the brain sciences could provide psychology
 - No tools to acquire insight about the cognitive operations in humans
 - Neuropsychology: the exception that proves the rule
 - From patients with brain damage, learn what psychological abilities can be dissociated
 - But little about what brain processes underlie them
- Beginning in the late 1980s
 - New techniques for studying brains of humans non-invasively (PET, fMRI)
 - Emergence of *cognitive neuroscience*
- Some philosophers start to question the multiple realizability argument:
 - Realization: brain science has long been a comparative science



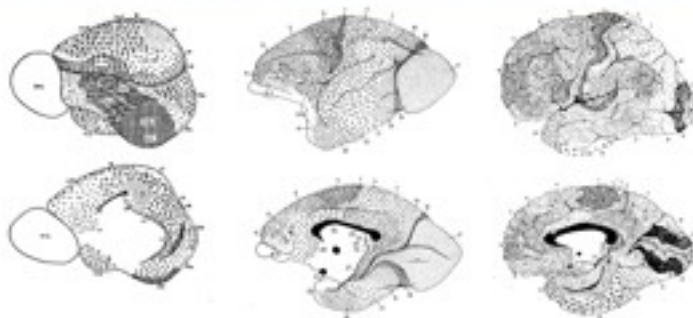
Mapping Structure Across the Brains of Different Species

- 19th Century: named the various gyri and sulci in the brain
 - Problem: variability
 - Explanation: not functional areas
- Korbinian Brodmann, 1909 (and others): use differences in composition of different brain areas to distinguish them
 - Took advantage of new stains (Golgi, Nissl, etc., that allowed for differentiating types of neurons)
 - Discovered layered nature of cortex, based on studies of 55 species from 11 orders of mammals



Brodmann's Brain Maps

- Cytoarchitectural maps of 3 different species (also included maps of two lower monkeys [guenon and marmoset], flying fox, kinkajou, rabbit, and ground squirrel)



Hedgehog

Lemur

Human

From Structural to Functional Maps

- Brodmann's explicit goal: provide a foundation for accounts of how brains function:
 - "Although my studies of localisation are based on purely anatomical considerations and were initially conceived to resolve only anatomical problems, from the outset my ultimate goal was the advancement of a theory of function and its pathological deviations" (1909/1994, 243).
- But Brodmann did not have the tools for studying brain functions or linking them to the regions he had identified

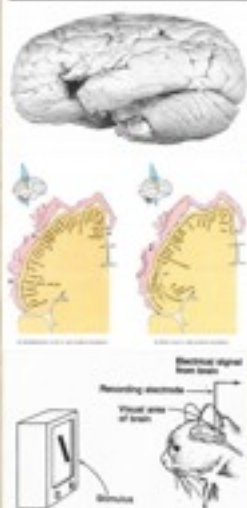
Clicker Question

Assume no one had yet figured out what functions were associated with any brain regions. What strategy would you adopt?

- A. Look for (or create) damage in a brain region and link it to the function that was lost
- B. Stimulate a brain region (e.g., by inserting an electrode and providing a pulse of current) and see what behavior is increased
- C. Present stimuli to the organism and record activity in various parts of the brain
- D. Other (be prepared to specify)

Pioneering studies linking brain regions to cognitive functions

- In the 1860s Broca studied patients with severe language impairments and, after they died, observed damage in the frontal cortex
- In the 1870s Fritsch and Hitzig stimulated areas in the brain of a dog finding ones that elicited motion
 - A technique used by Penfield to identify the sensory and motor homunculi
- By the 1960s it was possible to record from electrodes as visual stimuli were presented cats and monkeys
 - Same logic is used in classical neuroimaging studies



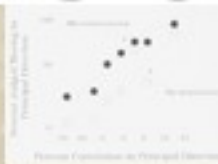
Using the Brain to Determine Functional Processes in Vision

- Identification of brain areas involved in vision revealed a host of different processing components that can be affected/damaged individually
 - Areas for shape, color, motion, etc.
- Two general processing streams (what/where) that are largely independent of each other
- This research is largely conducted on monkeys but applied to humans, apparently without worries about multiple realization



Example: Newsome's Study of Motion Perception

- In the 1974 Semir Zeki identified an area of the brain in front of striate cortex that responded to moving stimuli
- William Newsome showed:
 - Removing the area impaired the monkey's ability to respond to moving visual stimuli
 - Recording from the area when the stimuli were ambiguous enabled predictions of monkey responses
 - Stimulating the region increased likelihoods of particular responses



Rejecting the Multiple Realizability Argument

- The multiple realizability argument assumes that mental/functional states are the same across a wide range of organisms with wildly different brains
 - Pain and hunger are shared by us and octopi but our brains don't resemble each other
- But hunger and pain aren't that similar in different species
 - They result in very different behaviors
- And brains show more similarity than we thought
- Those defending multiple realizability have used different grains with respect to function and structure
 - Brains are different if we seem to detect differences
 - Minds are the same if we seem to find similarities

Apparent Multiple Realizations are Not Functionally Equivalent

- Primate versus octopus eye
 - Different visual pigments in their photoreceptors
 - Different retinas
 - Different ways of focusing light
- Result: functional differences
 - In the optic stimuli to which the eyes respond
 - In reaction times

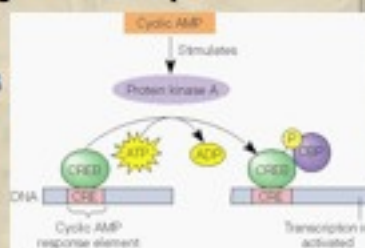
Clicker Question

How far down the phylogenetic scale do you think it is likely that scientists will be able to find commonalities useful for understanding thinking with our brains?

- A. Only within a given human
- B. Only within the human species
- C. With other vertebrates (mice, dogs, chimps, etc.)
- D. With other animals (e.g., fruit flies)
- E. With plants and bacteria

Shared Building Blocks

- "In all systems studied, the cAMP signaling cascade has been identified as one of the major biochemical pathways involved in modulating both neuronal and behavioral plasticity. ... More recently, elucidation of the role of CREB-mediated transcription in long-term memory in flies, LTP and long-term memory in vertebrates, and long-term facilitation in *A. californica* [a sea slug] suggest that CREB may constitute a universally conserved molecular switch for long term memory" (Dubnau & Tully, 1996, 438).



Larry Shapiro's Dilemma



- "Consider what appears to be a genuine case of multiple realizability, that is, two objects that "do the same thing" but in very different ways. Either the realizing kinds genuinely differ in their causally relevant properties or they do not. If they do not, then we don't really have a case of multiple realizability (like the corkscrews that differ only in color or composition). If they do, then they are different kinds. But then they are not the same kind and again we don't have an instance of multiple realizability—of a *single* kind with distinct realizations."

How Do Mental States Relate to the Brain?

- The multiple realizability argument against the Identity Theory no longer seems as so obviously correct as it once did
- Cognitive neuroscience is a flourishing research program trying to link psychological processes to the brain and study the brain processes involved
- Yet many philosophers still contend that function is what most characterizes mental states while others think they should be eliminated
- So still three main positions
 - Identity theory
 - Functionalism
 - Eliminativism